A new generation of high strength steel rolled sections

For some years now, the structural steel market has been moving towards an increasing use of products with greater thickness, higher yield strength, increased toughness and improved ductility.

The traditional method of producing high-strength steels consists of adding alloying elements to the steel bath and controlling the temperatures during the rolling process, by doing the so-called Thermo Mechanical (TM) rolling. Due to the limited allowable alloying elements and due to the mechanical power limits of the mills, Grade 355 MPa (50 ksi) has been the maximum quality possible for heavy shapes.

Starting in 1993, structural engineers have had the possibility to design steel structures with high-strength steel in medium and heavy rolled sections. Indeed, HISTAR 460 (HIgh STrength ARcelorMittal) steels covered by the European standard EN 10025-1 and the American ASTM A 913/A 913M "Standard Specification for High-Strength Low-Alloy Steel Shapes of Structural Quality, Produced by the Quenching and Self-Tempering Process, (QST)" allow the engineers to use Grades 355 MPa (50 ksi =345MPa) and 460 MPa (65 ksi = 450MPa) steels in their design.

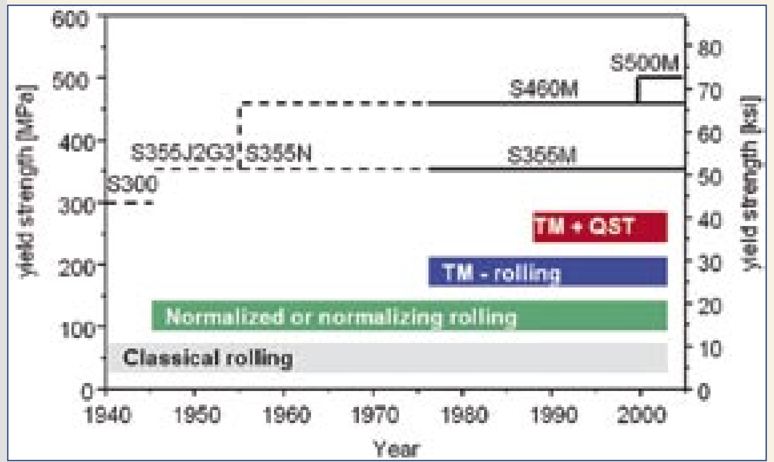
The QST process (Quenching + Self Tempering), referred to as HISTAR and ASTM A 913/ A 913 M, considerably increases the yield strength and the toughness of the steel. Simultaneously, due to much lower carbon equivalent values, it significantly improves the weldability of the beams without any loss of ductility.

TAILOR-MADE BEAMS.

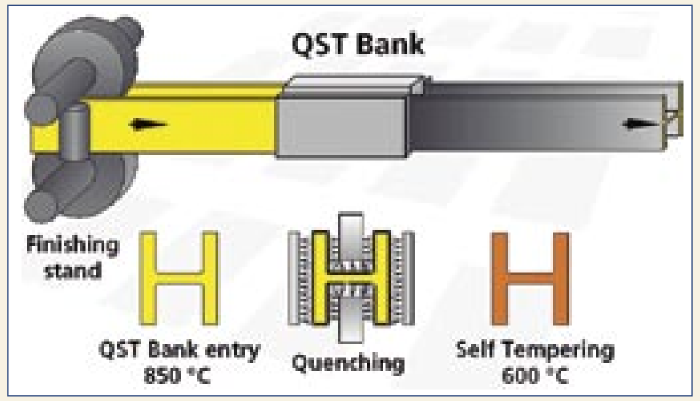
In 1979, ArcelorMittal (http://www.arcelormittal.com) (formerly ARBED) first introduced the Tailor-Made beams (called WTM). They were well accepted by both structural engineers and fabricators because of their cost-effective benefits. These WTMs have been used in more than 1000 projects in the U.S. and more than 1600 worldwide where built-up sections or concrete were previously required in spite of having one sole supplier of WTMs for many years. Nowadays, these WTMs are available from a few major suppliers.

QUENCHING AND SELF TEMPERING (QST) PROCESS.

Now, in addition to the Tailor-Made beam concept, ArcelorMittal provides the largest choice of steel grades as well, thanks to the QST process. In this process, an intense water-cooling is applied to the whole surface of the beam directly after the last rolling pass. Cooling is interrupted before the core is affected and the outer layers are tempered by the flow of heat from the core to the surface. The QST process considerably increases the yield strength and the toughness of the steel and due to much lower carbon equivalent values, simultaneously improves its weldability and keeps excellent ductility. A prerequisite for a successful QST treatment is a homogeneous temperature profile in the beam section before entering the cooling bank. This condition is fulfilled by applying a selective cooling during rolling to the hottest part of the beam, namely the flange-web intersection. By applying this selective cooling in the region of the flange-web junction, existing temperature differences can be eliminated. This process considerably improves the grain sizes and reduces the residual stresses in the core area of heavy shapes. This process is fully controlled by computer.



Steel grade	Yield Point , (N/mm^2)						Yield Strength (N/mm^2)		Max. Elongation, %
	Flange Thickness, From … To … (mm)						Nominal thickness, (mm)		
	до 16	16–40	40–63	63–80	80–100	100–125	3–100	100–125	
S235	235	225	215	215	215	195	340–370		22
S275	275	265	255	245	235	225	410–560	400–540	18
S355	355	345	335	325	315	295	490–630	470–630	18
S355	355	345	335	335	335	335	450–610		18
S460	460	440	430	430	430	430	530–720		22
Histar 355	355						470–610		22
Histar 460	460			450			550–720		17



SELECTIVE COOLING

The above picture schematically illustrates the QST treatment. At the exit of the finishing stand, directly at the entry of the cooling bank temperatures lie typically at 850°C. After the cooling over the whole surface of the section, a self-tempering temperature of 600°C is aimed for.

The below picture shows the operation at the mill of the QST process. The beam enters the finishing stand from the left hand side at about 850°C. The dark color of the beam leaving the cooling bank and the pink color on the right side demonstrates the efficiency of the cooling and the self-tempering process.

PROPERTIES OF QST STEELS.

The above table compares the mechanical properties of the most common European grades with HISTAR steels.

AVAILABLE SIZES

The full range of sections from 80 mm to 1100 mm and from 4,9 kg/m up to 1086 kg/m can be supplied according to different standards such as European (EN: IPE, HE, IPN, HD,...), American (ASTM : W, S, HP) or British (BS : UB, UC) standards.

Besides the beams, ArcelorMittal is also rolling a wide range of merchant bars such as angles, channels, flat bars, round bars,... The complete list as well as the sectional, mechanical and chemical properties can be downloaded on http://www.arcelormittal.com

Special sections, such as castellated beams or slim floor beams (IF, SF) are also available for respectively long span applications and buildings with minimum floor to floor distance.

If we compare the dimensions of the sections produced in Russia, they are very similar to the European ones. But the advantage of the European range is obvious. There are more sizes available in the EN. This allows the engineers to optimize his design due to the huge amount of available sizes.

WELDABILITY.

In 1998, ASTM A913 / Grades 345 and 450 MPa have been introduced in the AWS (American Welding Society) codes D1.1 in a category "weldable without preheating" if welded with low hydrogen (< 8 ml/100g) electrodes and when the outside temperature is above 0°C (32°F). The limitation of the maximum CE (Carbon Equivalent) in ASTM A913 guarantees the outstanding weldability of HISTAR steels. ASTM A913 grade 345 MPa and grade 450 MPa have respectively a maximum CE of 0.38 and 0.43.

The splicing by welding of the two heaviest sizes produced nowadays, HD 400x 1086 kg/m (W14x730 lbs/ft) in QST Grade 460 can be done without preheating. In order to achieve this splice, the welder needed 140 passes to weld the two pieces together. Thanks to QST beams, he didn't have to preheat the beam flanges and webs and saved about 4 hours of work. Because the most vulnerable size can be welded without preheating, smaller QST sizes can also be welded without preheating. For welding the same sizes in A572/Gr.50 steel, a preheating temperature of 110°C would have been needed as per AWS D1.1. codes.

WHEN TO USE A913/HISTAR STEELS?

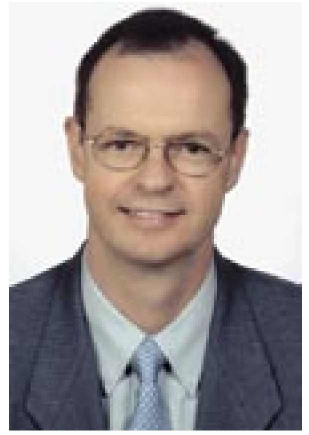
HISTAR 355 or ASTM A913/ grade 345MPa (50ksi).

HISTAR 355 and A913/grade 345MPa (50 ksi) should be used instead of a normal S355 steel or ASTM A572 /Grade 50 steel every time the welding procedure requests a preheating. The steel fabricators will be able to save the time and the propane needed for preheating normal 345 steels.

ASTM A913/grade 65 ksi (450 MPa) / HISTAR 460.

GRAVITY COLUMNS.

When the design is not governed by a drift or a vibration problem, HISTAR 460 in gravity columns with normal buckling lengths (typically less than 5.5 m) allows the engineer to reduce the weight and the cost of the structure. Indeed, the use of HISTAR 460 instead of 355 MPa or even 245 MPa allows the engineer to reduce dramatically the size of the column. In average, the weight of the columns can be reduced by 15 % compared to 355 MPa and more than 45 % compared to 245 MPa. Almost all buildings designed



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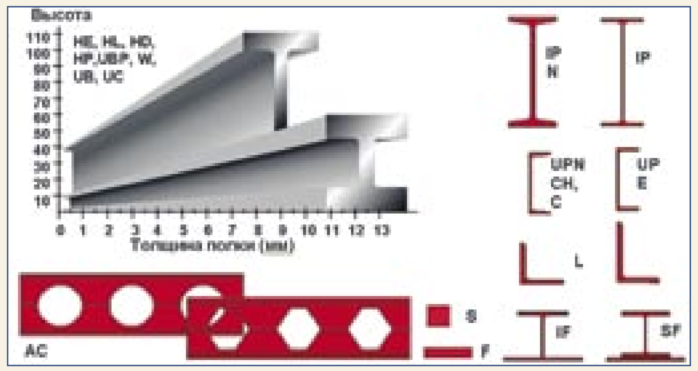

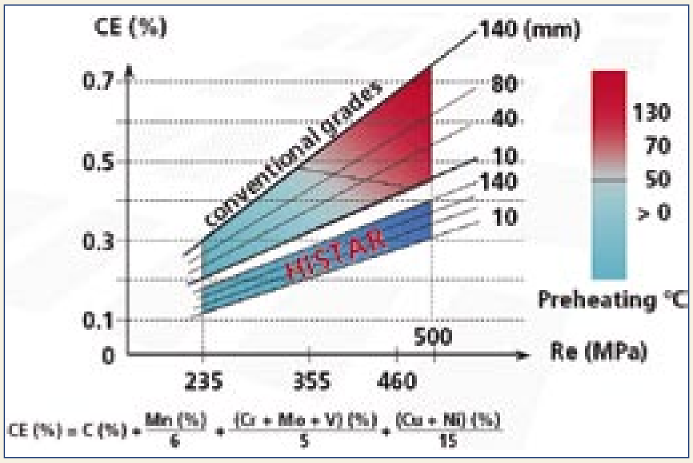

with a concrete core taking all the lateral loads can thus be designed with HISTAR 460 columns. It is also the case for gravity or high loaded columns used in power plants.

	Russian and EN sections classified by their elastic Modulus Wel,y						
		G	h	b	tw	tf	Wel,y
Standard	Designation	kg/m	mm	mm	mm	mm	mm3
							x103
EN	HE 100 B	20,4	100	100	6	10	89,91
EN	HE 120 A	19,9	114	120	5	8	106,3
GOST	16Б2	15,8	160	82	5	7,4	108,7
EN	IPE 160	15,8	160	82	5,0	7,4	109
EN	HE 140 AA	18,1	128	140	4,3	6	112,4
EN	IPE AA 180	14,9	176,4	91	4,3	6,2	116
GOST	18Б1	15,4	177	91	4,3	6,5	120,1
EN	IPE A 180	15,4	177	91	4,3	6,5	120
EN	HE 100 C	30,9	110	103	9	15	137,9
EN	HE 120 B	26,7	120	120	6,5	11	144,1
GOST	18Б2	18,8	180	91	5,3	8	146,3
EN	IPE 180	18,8	180	91	5,3	8,0	146
EN	HE 140 A	24,7	133	140	5,5	8,5	155,4
EN	IPE AA 200	18,0	196,4	100	4,5	6,7	156
EN	IPE A 200	18,4	197	100	4,5	7,0	162
EN	IPE O 180+	21,3	182	92	6,0	9,0	165
EN	HE 160 AA	23,8	148	160	4,5	7	173,4
EN	HE 100 M	41,8	120	106	12	20	190,4
GOST	20Б1	22,4	200	100	5,6	8,5	194,3
EN	IPE 200	22,4	200	100	5,6	8,5	194
EN	IPE AA 220	21,2	216,4	110	4,7	7,4	205
EN	IPE A 220	22,2	217	110	5,0	7,7	214
EN	HE 120 C	39,2	130	123	9,5	16	213,6
EN	HE 140 B	33,7	140	140	7	12	215,6
EN	IPE O 200	25,1	202	102	6,2	9,5	219
EN	HE 160 A	30,4	152	160	6	9	220,1
EN	HE 180 AA	28,7	167	180	5	7,5	235,6

TRUSSES.

The best use of HISTAR 460 or A913/Gr.450 (65 ksi) is in tension members such as the typical bottom chord of a truss or in compression members with short buckling length such as the top chords of the truss. HISTAR 460 in a truss generally allows a reduction of minimum 15 % compared to classical solution in Grade 355 (50ksi). This reduction in weight is a function of the span of the trusses and the importance of the dead loads on the design. For the new assembly plant of the Boeing 777 closed to Seattle, the weight savings was 35 % compared to grade 355 due to the long span (108 m) of the trusses. This project, built in 1991 was the first project in the US using QST beams, even before the approval of ASTM A913. Another advantage is the weldability without preheating of all the splices as mentioned earlier.

SEISMIC DESIGN.

The use of HISTAR 460 and 355 allows the engineer to design a moment frame structure with the economical "strong column - weak beam" concept which is commonly used on the West Coast of the United States.

Combined with the RBS (Reduced Beams Section), it gives to the engineer the possibility to design a connection 100 % safe under seismic loading conditions. The RBS or sometimes called "Dog Bone Connection" was patented by ArcelorMittal (ARBED) in 1989. After the Northridge earthquake, ArcelorMittal decided to release this patent in order to offer this concept to the engineering community.

Strong Column (65 ksi / Grade 450 MPa) – Weak Beam (50 ksi / Grade 345 MPa) concept + RBS connection (199 Fremont Street San Francisco)

OFFSHORE PLATFORMS.

Due to its high level of toughness at low temperature, (up to 27 J at -50°C) and their outstanding weldability, HISTAR 355, 460 or A913 steels are prefect for offshore applications, especially in cold area.

HISTAR IN RUSSIA.

HISTAR steels are approved by the Melnikov CRDISBS, Kucherenko CRISBS as compliant with the building regulations and recommended standards of СП 53-102-2004. The full report is available on request. (anton.chudaev@arcelormittal.com)

HISTAR steels from ArcelorMittal are helping redefining the skyline of Moscow. In 2005, ten thousands tons of HISTAR steel, labeled HISTAR Russia due to their special "Tailor-Made" for the cold weather in Moscow have been supplied to the Turkish contractor Enka for manufacturing and erecting the tower in MIBC "Moscow City" (lot N°10). In 2006, it is more than 12,000 tons of sections that have been used for plot N°12. And last year, some steel sections have been used in the "A" tower of the Federation towers complex.

New high performance steels such as HISTAR are available today on the worldwide market. These steels offer properties that were impossible to achieve two decades ago: higher yield point up to 450 MPa for rolled sections with a flange thickness up to 125 mm, outstanding toughness up to -50°C and much lower carbon equivalent improving the weldability without loss of ductility.

Since 1993, many structural engineers understood the potential of high strength steels rolled sections. The recent landmark projects in Moscow are indicating that they will also be very popular in Russia in a near future. ■